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July 21, 1983

Mark Grussendorf
U.S. Department of the Interior
Minerals Management Service
Reston, VA 22091

RE: OCSEAP P.1. Report

Dear Mark:

Enclosed you will find the Partial-Final Report for RU 611, Citation #4089, which has been approved by the appropriate contract supervisor Guy W. Oliver

Sincerely,

Charles J. Paul
Publications Clerk

Enclosure (2 Reports)

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JUL 26 1983

Copy to Tim Sullivan
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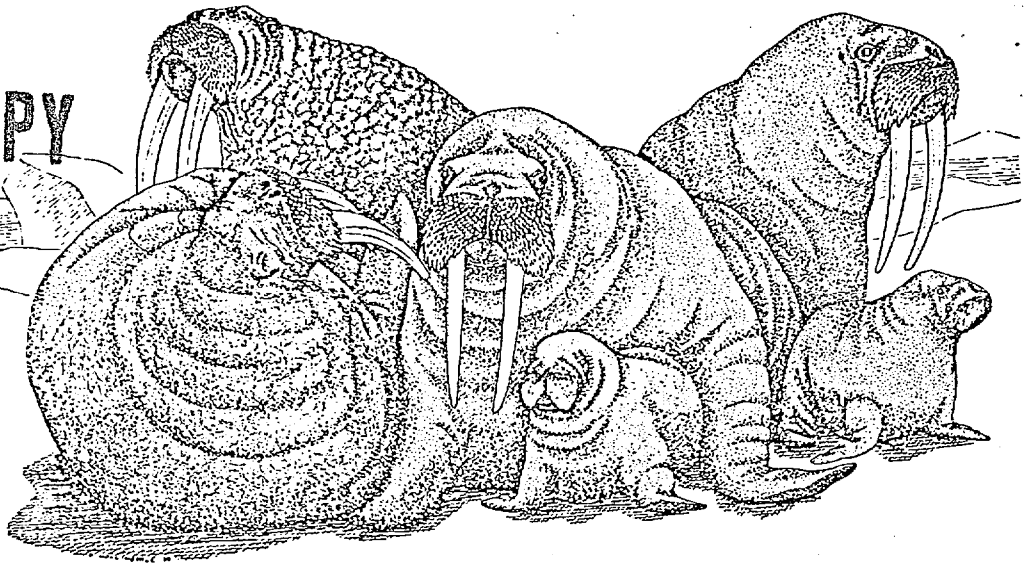

PACIFIC WALRUS

by

Brendan P. Kelly
Division of Life Sciences
University of Alaska

INTRODUCTION

The walrus *(Odobenus rosmarus)* is the only living representative of the family Odobenidae, which diverged from the same ancestral stock as the Otariidae (fur seals and sea lions) about 15 million years ago (Repenning and Tedford, 1977). Two subspecies are recognized; *O. r. rosmarus* of the North Atlantic Ocean and O. *r. divergens* of the North Pacific Ocean. A third subspecies in the Laptev Sea is recognized in the Soviet Union (Chapskii, 1940) but has not received general acceptance (Fay in press). Yupik-speaking Eskimos call the walrus "asveq," "Kaugpak," or (on St. Lawrence Island) "ayveq," Inupiaq speakers say "aivik," the Aleut term is "amak" or "amaghak." Numerous other Eskimo terms designate walruses of particular ages, sexes, and body conditions.

Pacific walruses are large, robust mammals with a midbody girth approximately equal to the nose-tail length (Fay in press). Adult males average 3.2 m in length and 1210 kg in weight versus 2.7 m and 830 kg for adult females (Fay in prep.). As in other pinnipeds, the body is somewhat fusiform but heavier in the neck and shoulders than in the other species. The eyes are relatively small, and there are no external ear pinnae. The external nares are situated dorsally, just behind the upper edge of the squarish snout, the anterior surface of which is covered with hundreds of stiff sensory hairs, the mystacial vibrissae. The mouth is small, and enlarged upper canine teeth project downward as tusks from each side of it.

A short coat of tawny hair covers the head and body; the flippers are hairless. Color varies with age, sex, and skin temperature. The youngest. animals tend to be darkest; old males are lightest. A restriction of blood flow to the skin during immersion in cold water causes the skin to appear pale, almost white. Under warmer conditions such as when the animals are basking in the sun on shore, the skin is perfused with blood, giving it a distinctive reddish color.

In the water walruses swim with a sculling motion of the hind flippers as do the hair seals *(Phocidae)*. On shore (or ice), locomotion is quadrupedal with hind flippers turned forward and fore flippers turned back, in the manner of the fur seals and sea lions *(Otariidae)*.

Walruses are sexually dimorphic but to a lesser degree than are the otariids and elephant seals. Adult males are paler, approximately 50% heavier, and have a larger, blockier head than adult females. At sexual maturity, bulls develop raised nodules in the skin on the neck and shoulders; nodules are absent in females and immature males. Tusks of males tend to be stouter, straighter, and mo eliptical in cross section than those c females.

WORLD DISTRIBUTION AND ABUNDANCE

Walruses are nearly circumpolar in distribution (Fig. 1), generally occurring between the July 10° C isotherm of air temperature and the edge of the permanent polar pack ice (Scheffer, 1958; Fay and Ray, 1968). At present, the pacific walrus of "the Bering-Chukchi region makes up approximately 80% of the world population (Reeves, 1978; Estes and Gol'tsev, 1980; Fay in press). Those in the eastern Canadian Arctic and West Greenland make up approximately 10%, and each of the four remaining populations comprises less than 2% of the total (Mansfield, 1966; Fay in press). Commercial hunting from the late 18th century through the early 20th century greatly reduced all walrus populations; only the Pacific walrus appears to have fully recovered from that event. Currently the world population numbers approximately 250 thousand animals.

Females and young mostly occupy the moving pack ice year-round, migrating northward in spring and southward

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Figure 1: World-wide distribution of walruses.

in autumn. Bulls also inhabit the pack ice during the winter months, but a large proportion of them spends summer months in ice-free waters, utilizing small islands and peninsulas as haul-out areas. Wanderers have been reported south as far as Nova Scotia and the Netherlands in the Atlantic (Mercer, 1967; Van Bree, 1977), and Honshu Island (Japan) and Prince William Sound (Alaska) in the Pacific (Scheffer, 1958; Fay, 1957).

ALASKAN DISTRIBUTION AND ABUNDANCE

Seasonal distribution is best understood in the case of the Pacific walrus. In general, Pacific walruses are restricted by their benthic feeding habits to the shallow waters of the Bering and Chukchi shelves (Fig. 2). Additional limitations in the summer months appear to be the permanent pack ice to the north and, possibly, high temperatures to the south (Fay and Ray, 1968; Ray and Fay, 1968). Winter distribution is mainly limited to areas of ice divergence in the Bering Sea where depths are less than 100 meters.

During January, February, and March, Pacific walruses appear to cluster in two areas, one immediately southwest of St. Lawrence Island and the other in outer Bristol Bay (Fig. 3). There are, however, no distributional data from the western Bering Sea during that period, and it is conceivable that there are other winter concentrations in that region.

As air temperatures increase in April, the Bering Sea pack ice begins to loosen. At the same time, the walruses begin to spread northward (Fig. 4). Some of the animals that wintered in Bristol Bay move northward along the Alaskan west coast, while others move northwestward toward the Gulf of Anadyr. The animals southwest of St. Lawrence Island appear to spread westward into the Gulf of Anadyr and northward toward Bering Strait.

More rapid melting and decreased southward movement of the Bering Sea ice takes place during May (Muench and Ahlnas, 1976), and the eastern Chukchi flaw opens widely at this time. Most of the population appears to be concentrated between St. Lawrence Island and Bering Strait, but a few reach Point Barrow this early (Fig. 5), and major concentrations occur along the Alaskan coast from the Alaska Peninsula to Norton Sound.

Most of the population moves northward through Bering Strait in June, but several thousand animals, mainly males, remain for the summer in the Gulf of Anadyr and in Bristol Bay (Fig. 6). As the Chukchi pack ice recedes, a second major flaw develops along the north side of the Chukchi Peninsula allowing some walruses to move northwestward as far as Wrangell Island.

In July the population north of Bering Strait continues its northward movement as the pack ice recedes (Fig. 7). Along the eastern side of the Chukchi Sea the largest concentrations of walruses occur between 70° N and the vicinity of Point Barrow. On the western side large concentrations are found from Bering Strait to Wrangell Island. Concentrations of males remain in the Bering Sea in Bristol Bay and the northern Gulf of Anadyr.

Throughout August "and much of September the distribution is much the same as in July but the northern limit is increased to approximately 76° N, just beyond the minimum extent of the pack ice (Fig. 8). During these months most of the population is concentrated in the vicinity of Wrangell Island and Barrow. Southward migration begins in the latter part of September, with most of the animals swimming ahead of the advancing ice. By late September some migrating animals have reached St. Lawrence Island and the Alaskan coast south to the Kuskokwim River. Summering herds in the Gulf of Anadyr usually leave their haul-out areas at this time.

Rapid advance of the Chukchi pack ice in October forces the last of the animals out of the Chukchi Sea, into the Bering Strait area (Fig. 9). Large herds of migrants appear on Big Diomede,

Figure 2: Place names within the range of Pacific walruses.

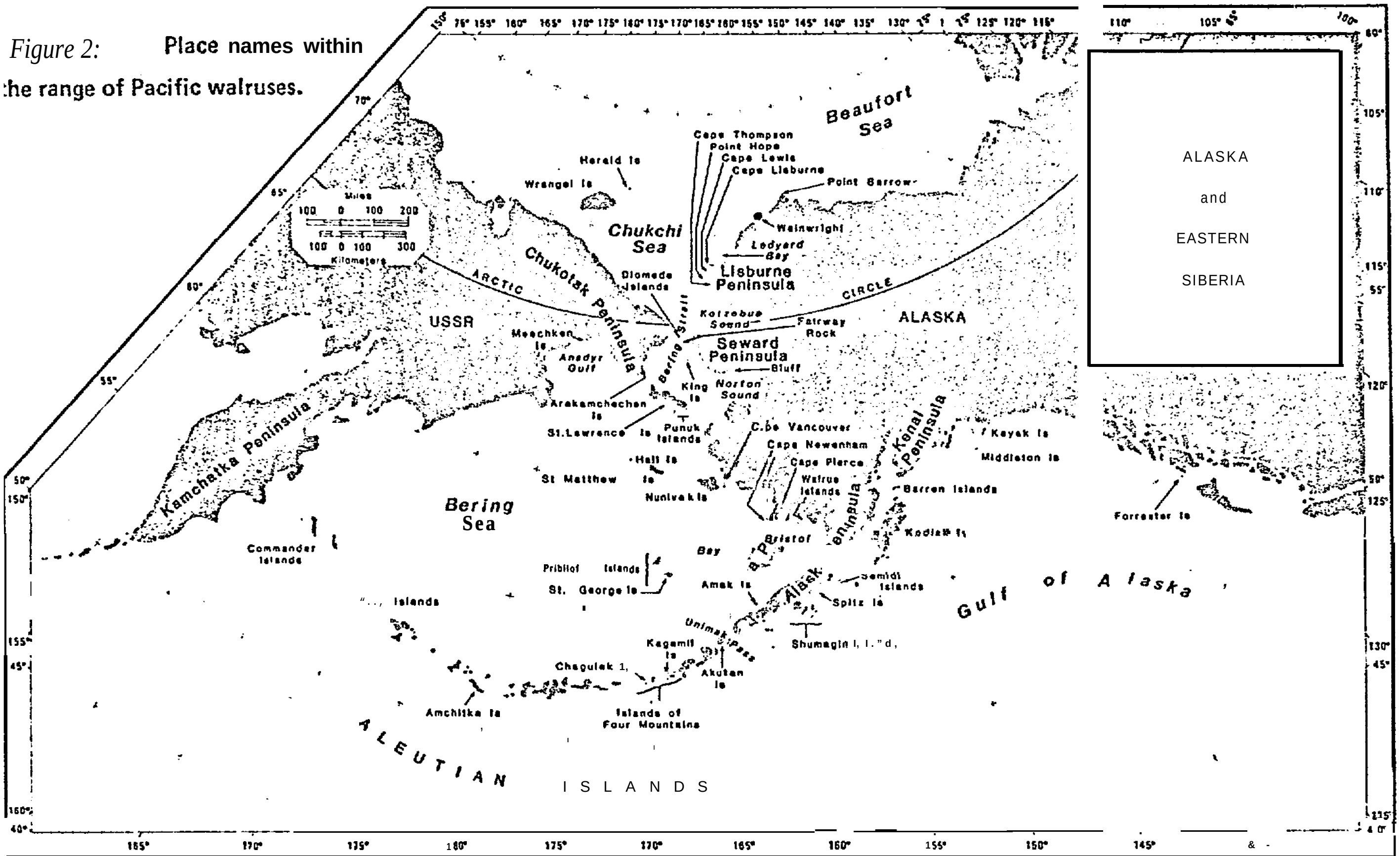
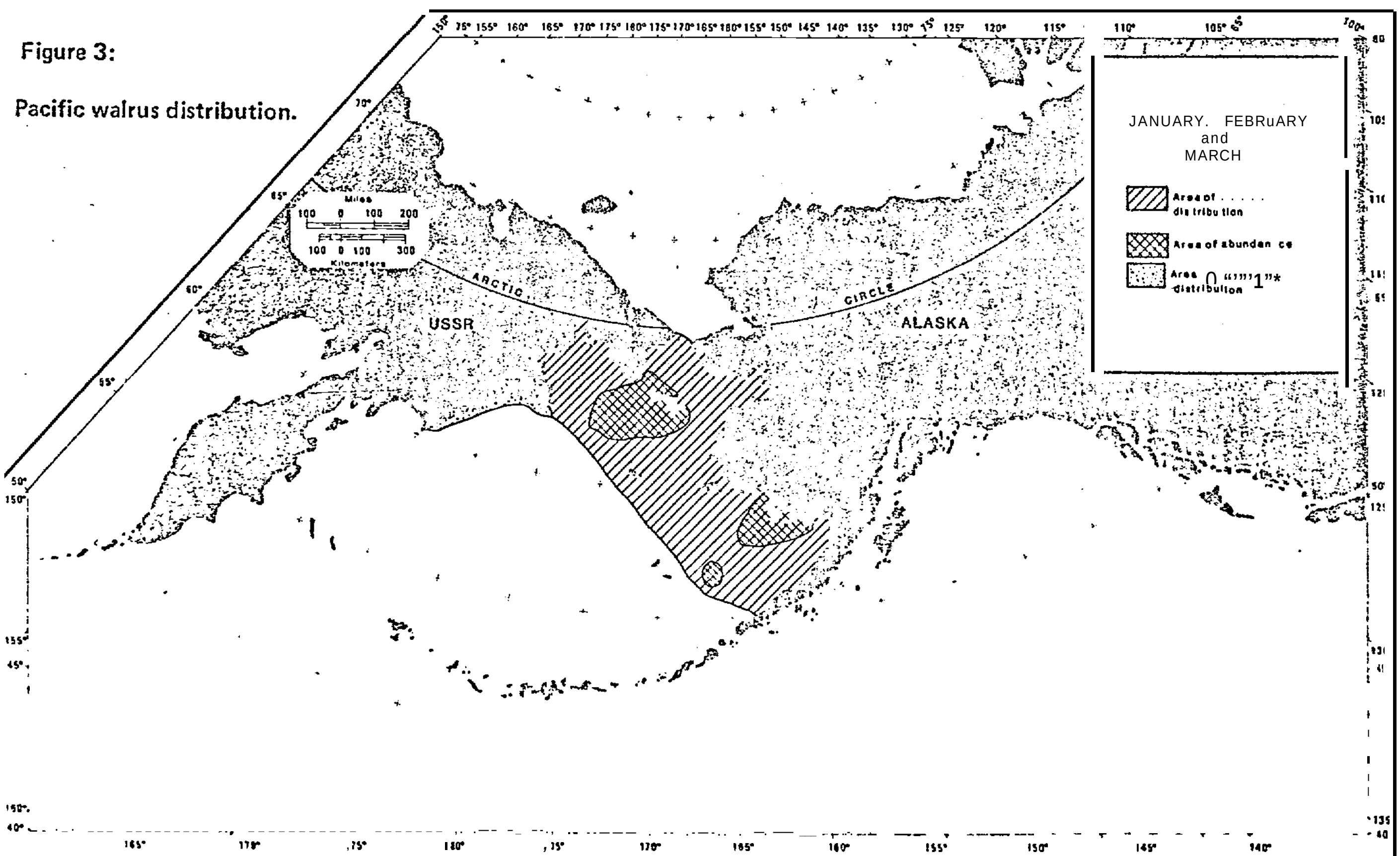


Figure 3:

Pacific walrus distribution.



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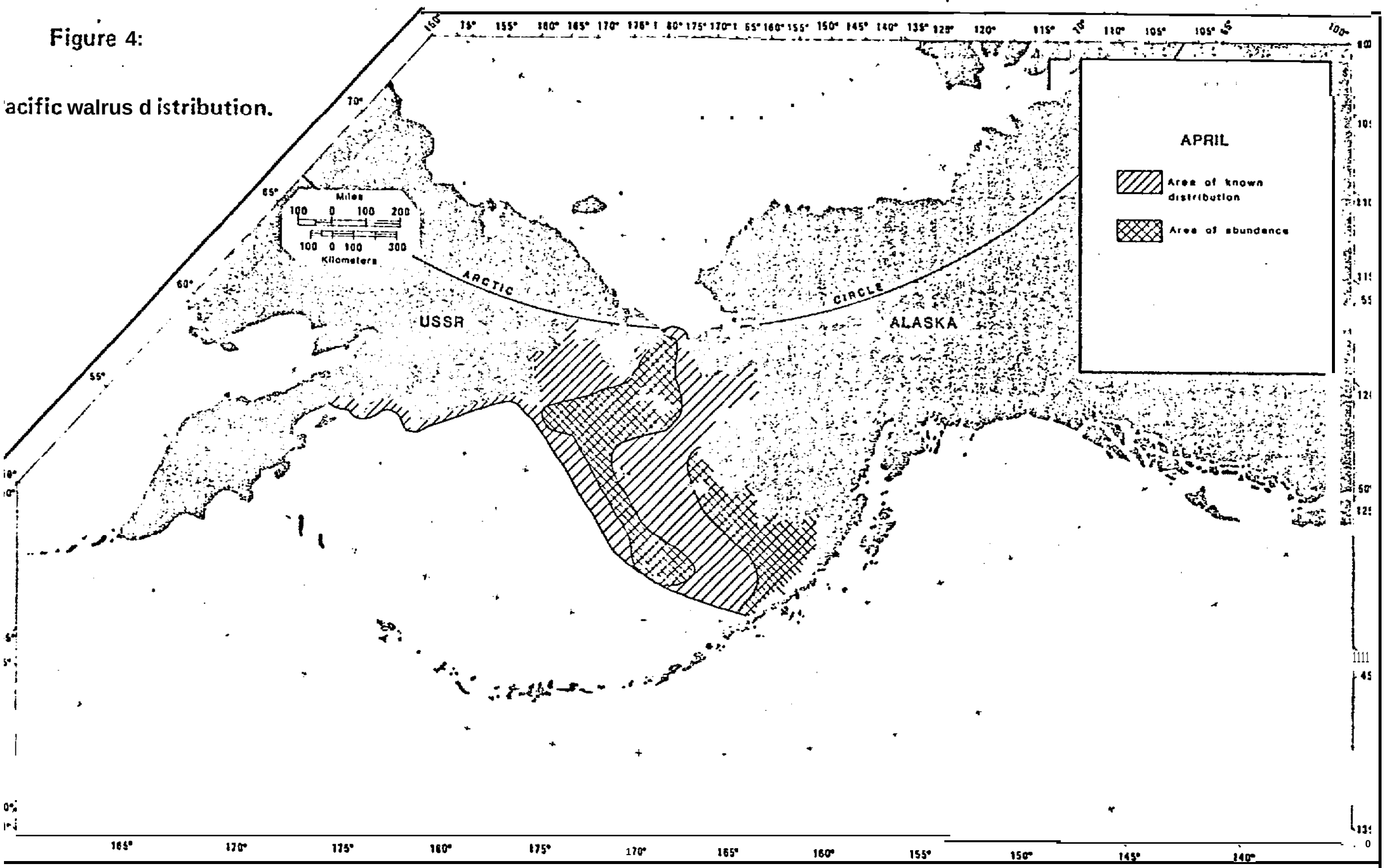

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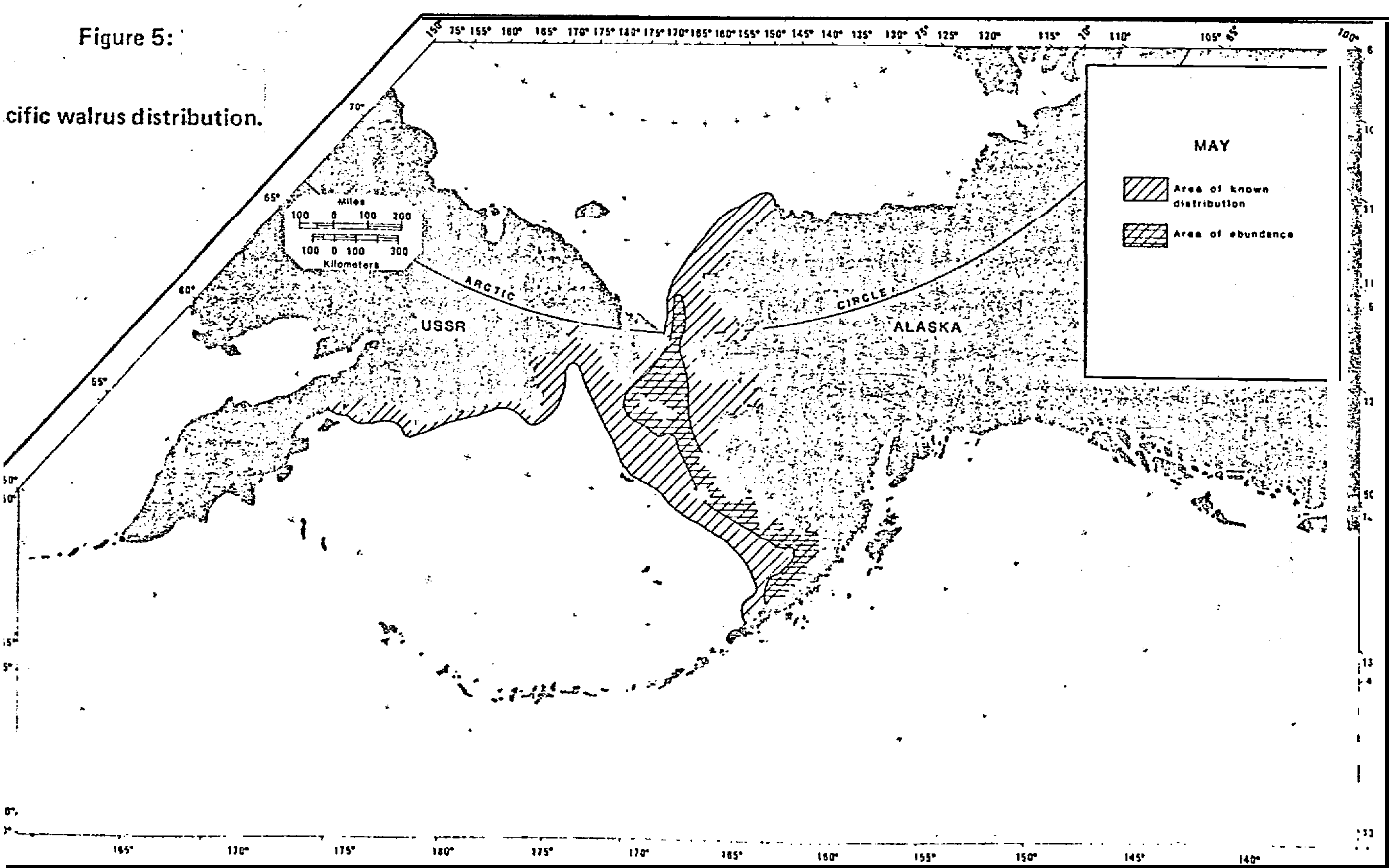


Figure 8:

Pacific walrus distribution.

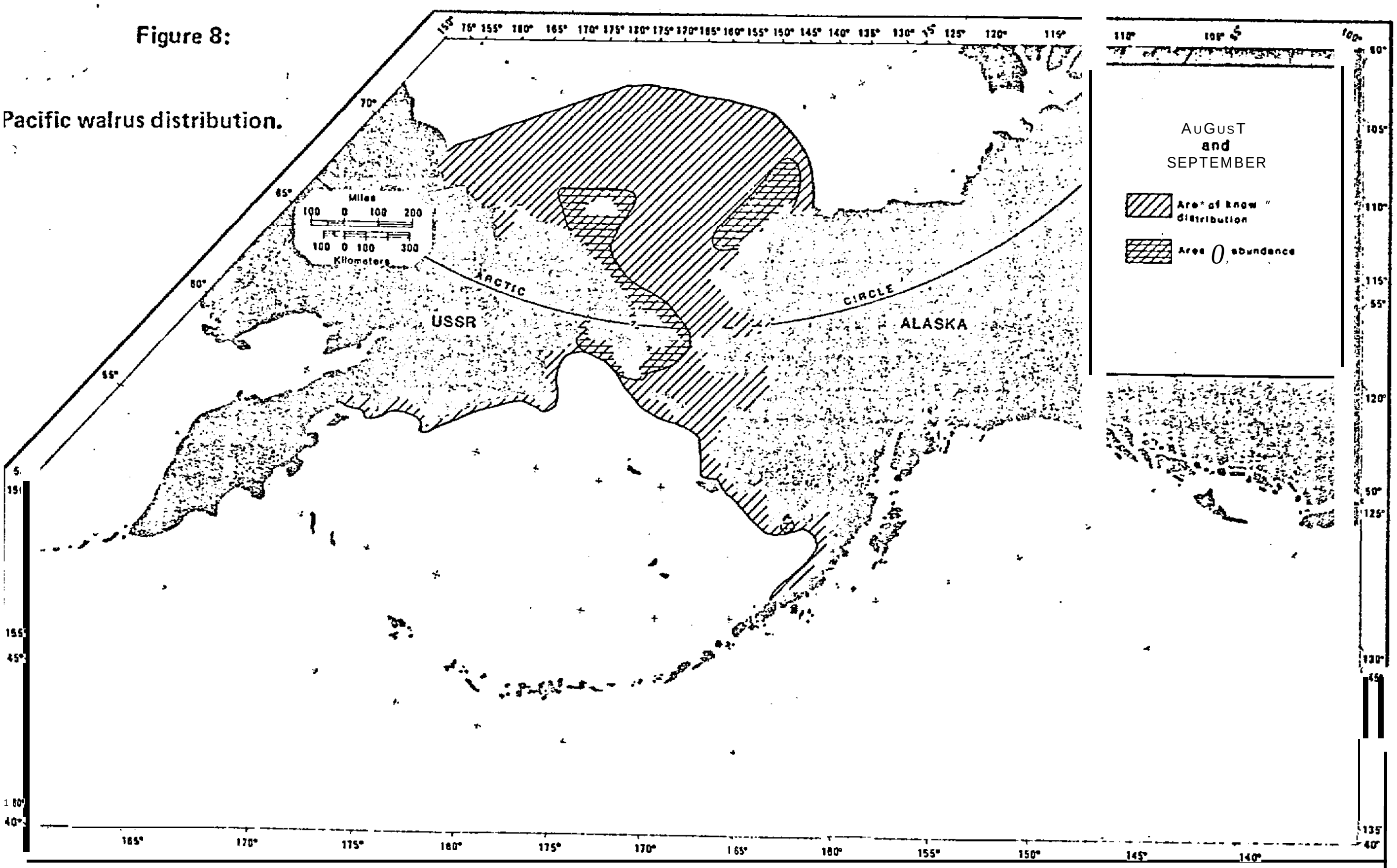
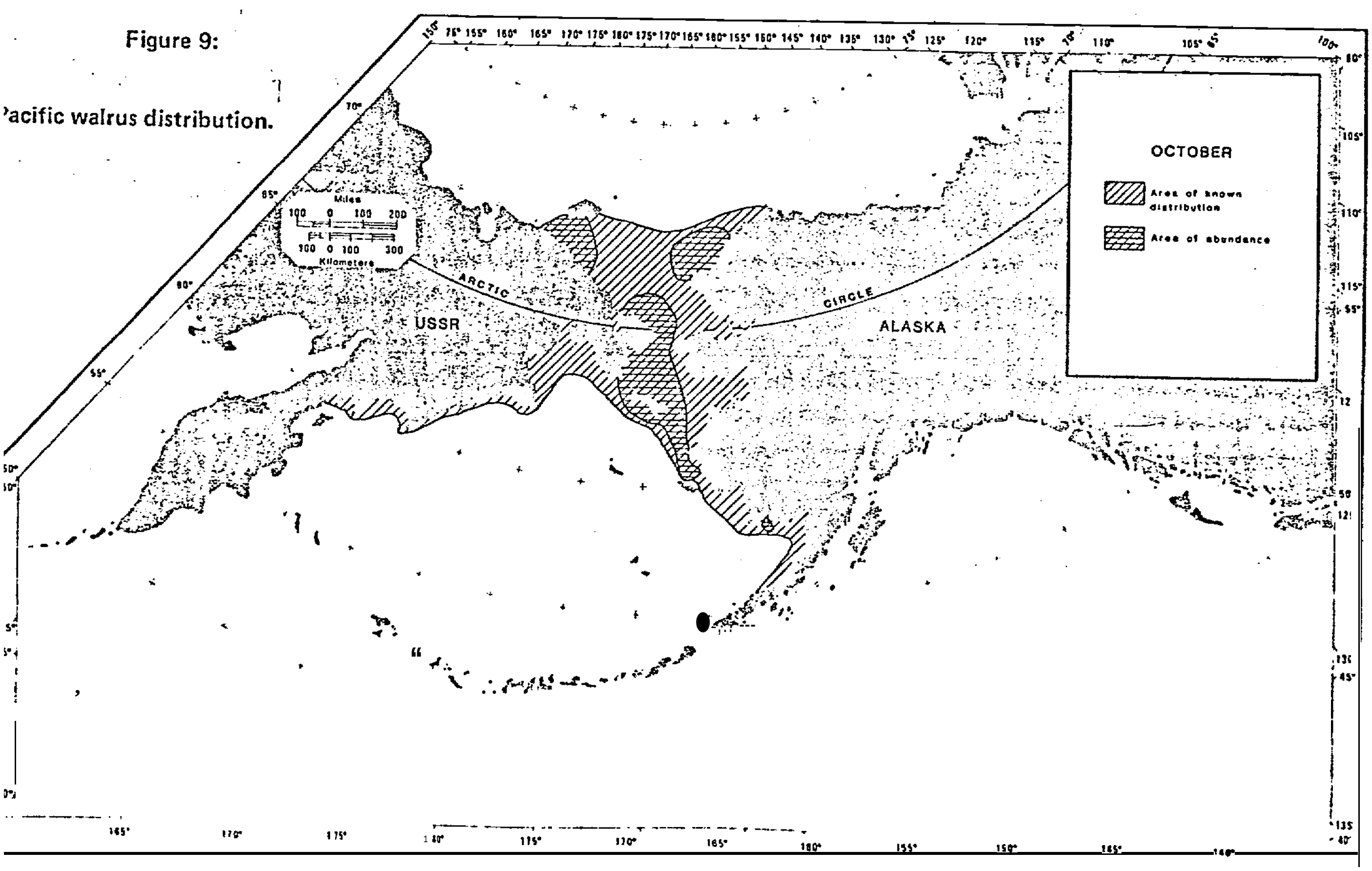


Figure 9:

Pacific walrus distribution.



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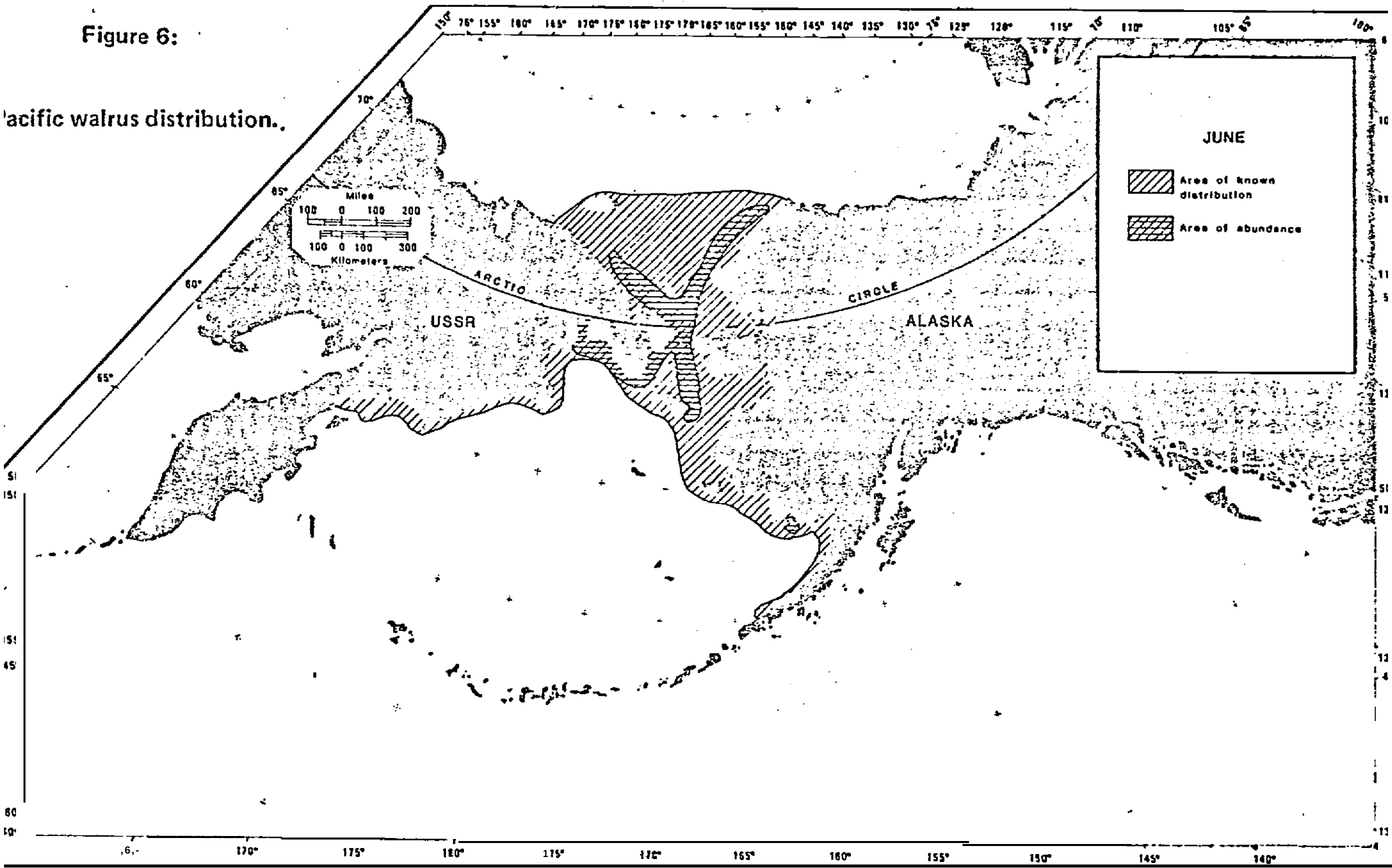

Figure 7:

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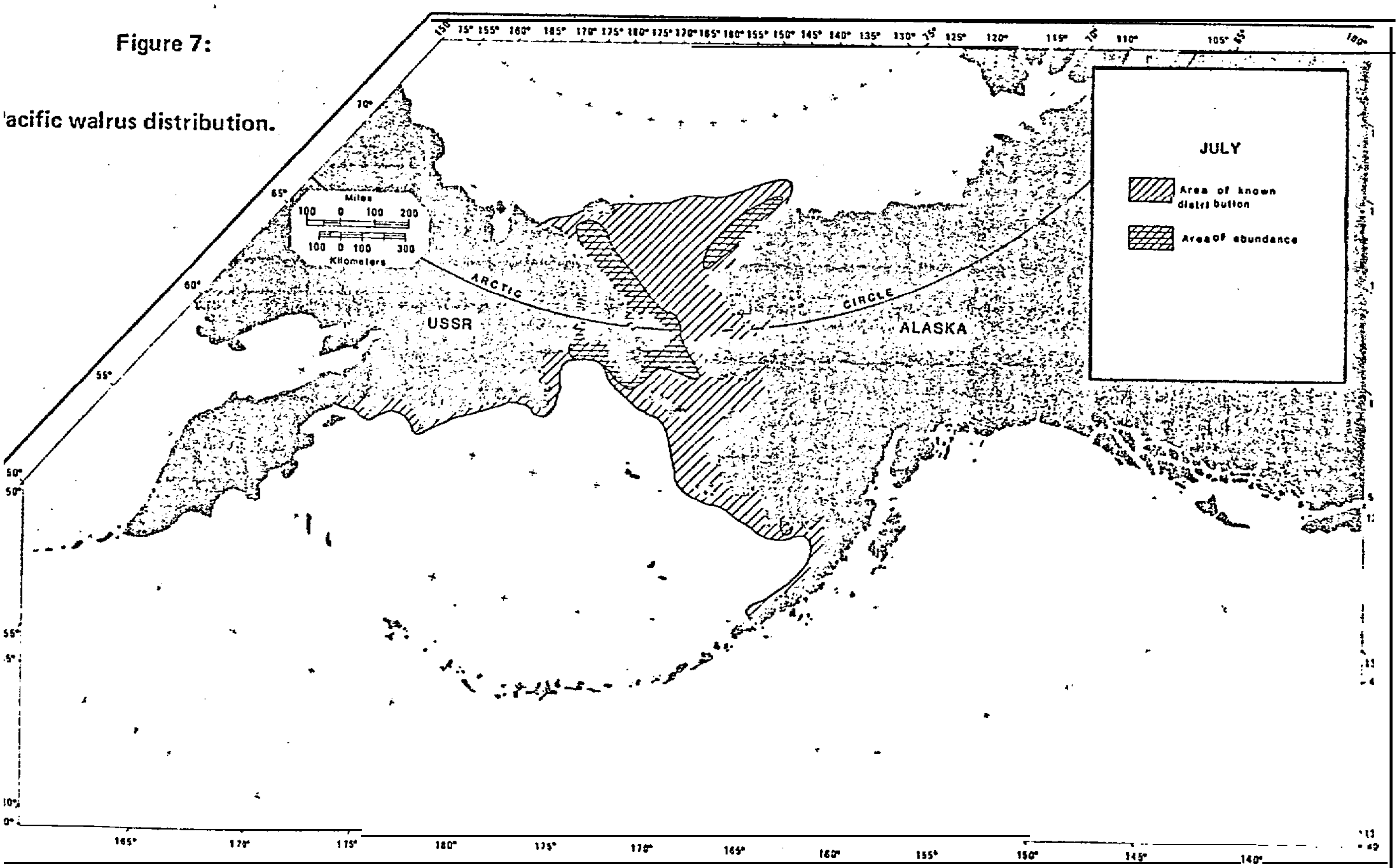


Figure 10:

Pacific walrus distribution.

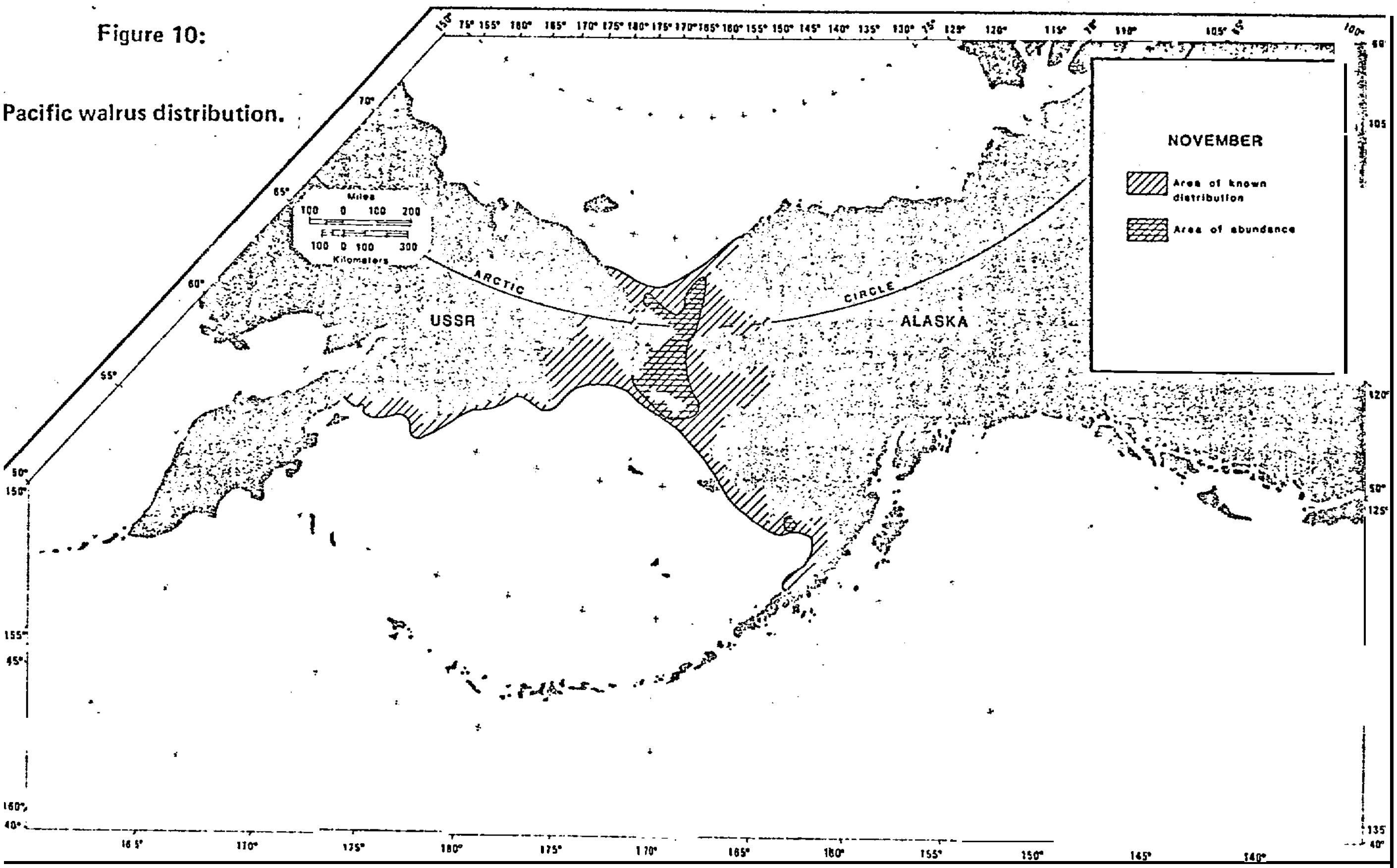
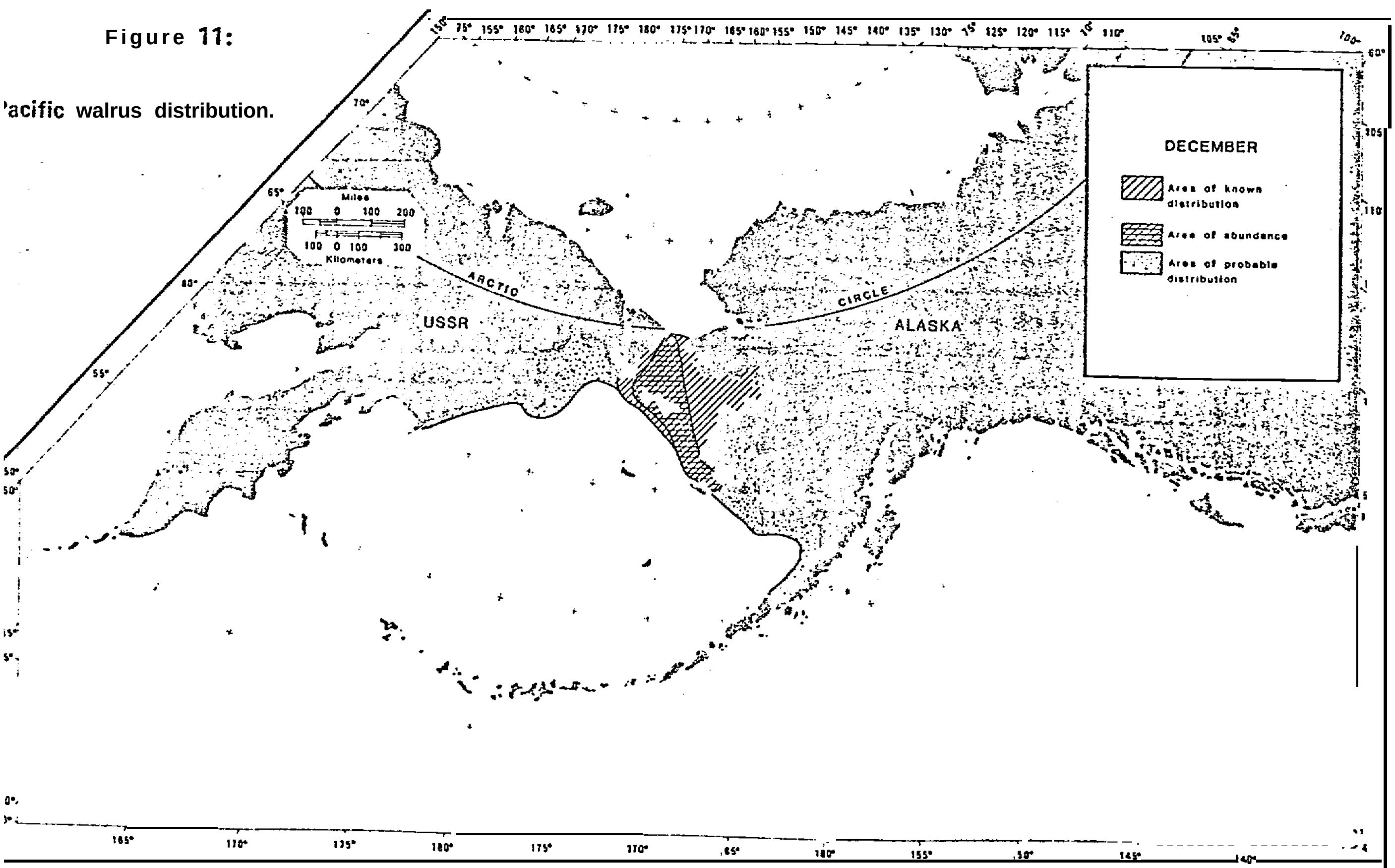


Figure 11:

'acific walrus distribution.



King, St. Lawrence, and the Punuk Islands, and some occur as far south as Nunivak and Nelson Islands. Although distributional data are scarce for November and especially for December, the continuing advance of the ice clearly pushes the population south of Bering Strait by early to mid-December (Fig. 10). Herds of several thousand walruses remain on Big Diomede, Arakamchechen, St. Lawrence, and the Punuk Islands, at least through November.

Estimates of walrus abundance are imprecise due to their nonrandom distribution, large variations in group size, and insufficient basic information on the animals' activity patterns (Estes and Gilbert, 1978). The most recent (1975) of these estimates would put the size of the Pacific walrus population at 209 thousand plus or minus 41 thousand animals (Gel'tsev, 1976; Estes and Gilbert, 1978). Indirect indicators of the population status suggest that it has reached or is approaching its upper limit (Fay and Kelly in press; Fay in prep.).

FOOD HABITS

Walruses are benthic feeders, eating mostly invertebrates that live on or close to the surface of the bottom sediments. The bulk of the Pacific walrus' diet consists of bivalve mollusks, especially *Mya truncata*, *Serripes groenlandicus*, *Hiatella arctica*, and *Spisula* sp. (Fay et al., 1977). Invertebrate foods of secondary importance (in terms of volume) include *Nephthys* sp. (Annelida), *Echiurus echiurus* (Echiurida), several species of gastropod mollusks, some crustaceans, holothurian echinoderms, and *Pelonaia corrugata* (Urochordata). Over 65 species of prey have been identified from walrus stomachs but it is difficult to assess the importance of each in the diet. Some may be ingested adventitiously, while others may be sought selectively. Little is known about the nutritional importance of the food items. Foods taken only in small quantities may be of great importance in providing essential nutrients.

Fishes are rarely consumed by Pacific walruses (Delyamure, 1 '355; Delyamure and Popov, 1975; Krylov, 1971). Phocid seals are more frequently eaten, but there is uncertainty whether they are killed by walruses or taken only as carrion. Remains of ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) have been found with a frequency of one to ten percent in walrus stomachs (Fay, 1960; Krylov, 1971). In all but one instance, walruses reported to have fed on seals were males. Fay (in prep.) suggested that consumption of seals might be in response to iron deficiency in the diet. Presumably, males have greater need for iron because of greater blood loss from wounds. The occurrence of *Trichinella spiralis* (the nematode which causes trichinosis) in walruses may be a result of their feeding on seals. Rausch (1 970) reported a *Trichinella* infection rate of one to nine percent in walruses.

Evidence from collected specimens and reports from native hunters suggest that there are regional and seasonal variations in the composition of the walruses' diet, but the data are insufficient for definite conclusions. Fay et al. (1977) showed that the species composition of food items in male and female stomachs were similar but that males consumed larger prey than did females.

Calves generally nurse for their first two years but begin to feed on invertebrates in the first winter (Chapskii, 1936; Mansfield, 1958). The milk is high in fat (approximately 30%) and, before solid foods are taken, is consumed at a rate of at least six to seven percent of the calf's body weight per day (Fay in prep.).

Feeding occurs throughout the walruses' range to depths of 80 meters. A typical feeding dive lasts from 5 to 10 minutes followed by a one- to two-minute surface interval (Tomilin and Kibal'chich, 1975; Loughrey, 1959; Fay in prep.). Walruses apparently spend 8 to 12 hours per day feeding (Vibe, 1950), but not in any consistent diet pattern. Fay (in prep.) estimated that the intake of food per walrus averages 50 to 80 kg per day and that the biomass of mollusks actually destroyed by this feeding amounts to three or four times that amount, since only certain of the soft parts of the prey are consumed.

The walrus probably locates its food tactually, by means of the highly sensitive and mobile mystacial vibrissae (Fay in prep.). With head down. and vibrissae in contact with the bottom, the walrus proceeds forward, propelling itself by sculling with the hind flippers (Fay in prep.]. Most food is encountered at the surface of the bottom sediments but some must be dug out. Such digging probably is accomplished by "rooting" with the snout, pig-fashion, rather than with the tusks (Fay in prep.). Prey are manipulated by the lips and grasped with the aid of roughly textured gums, rather than by the teeth. The soft parts of mollusks are removed from the shells by suction, and the shells are then ejected. Occasionally, small mollusks less than 30 mm in diameter are swallowed whole, shells and all, but from the larger mollusks, only the siphon or foot ordinarily is ingested (Vibe, 1950; Fay in prep.). Invertebrates without shells are swallowed whole without mastication.

BREEDING AND REPRODUCTIVE CYCLES

Mating takes place from December to April, mostly in January to March (Fay et al., 1980; Fay in prep.). At that time of year the population is concentrated on the pack ice southwest of St. Lawrence Island and in the Bristol Bay region (Figs. 3 and 4). Mature bulls court with elaborate displays in the water alongside groups of females resting on ice floes. Copulation presumably occurs in the water but has not been observed. No further paternal role is evident after mating.

Implantation of the blastocyst is delayed approximately four months and is followed by an 1 l-month gestation period. Calving takes place from mid-April to mid-June during the northward migration (Fay et al., 1980). A single calf is born; twins are rare (Nikulin, 1954; Krylov, 1962). The calf is closely attended by the cow and typically nurses for two years. Extensive physical contact between cow and newborn calf appears to be essential for the maintenance of the latter's body temperature (Fay and Ray, 1968). Weaning occurs gradually

›ver the' course of the second year Chapskii, 1936; Brooks, 1 954; Aansfield, 1958). The weight at birth, I5 to 75 kg, almost doubles in the first ix months and triples by one year of age Fay in prep.).

Most females are capable of reprolucing at five or six years old (Krylov, 1966); males generally are capable in heir ninth or tenth year (Krylov, 1967; ;ay in prep.). Males, however, are not hysically mature and able to compete uccessfully for females until they are ibout 15 years old. Fecundity of females lecreases after 15 years of age (Krylov, 962; Fay in prep.). The maximum life pan appears to be about 40 years. The reeding system is not well known but ;ay et al. (1980) presented evidence f a polygynous system, essentially a 'mobile lek." Females generally breed n alternate years due to their prolonged, 5-month pregnancy. Most older females roduce young at three- or four-year ntervals (Krylov, 1'362; Fay in prep.).

AORBIDITY AND MORTALITY

Fay et al. (1978) have reported ımbilical hernia, acute pneumonitis, ystic ovaries, uterine tumors, kidney tones, pleural fibropapilloma, biliary ibrosis and dermotomycosis in Pacific valruses. Only the first two of those onditions resulted in mortality.

Fourteen helminth parasites have ieen reported from walruses (Delyamure, 955; Yurakhno and Treschev, 1972;)elyamure and Popov, 1975). None of 1ese is known to be directly responsible or mortalities although liver infections f *Orthosplanchnus* sp. may cause biliary brosis as in bearded seals (Fay in prep.; hults pers. comm.).

Predators, other than man, are olar bears and killer whales. Bears pparently take only calves, usually on ie ice. The whales. however, kill both alves and adults in the water by ramming iem from below. The calves usually re consumed by the whales, but the dults, apparently, are not eaten.

Rock slides have been documented s an occasional cause of mortality on lound Island in Bristol Bay (Taggart nd Zabel unpublished; Kelly and O'Connor. 1979) and may occur on other coastal hauling grounds.

The use of tusks in intra-specific fighting results in bruises and sometimes bleeding wounds. The latter occur most frequently in breeding males, presumably the result of inter-male competition (Fay in prep.).

Fay and Kelly (in press) described a mass mortality that apparently resulted from stampedes of unusually large herds on hauling grounds in the St. Lawrence Island area. The proximal cause of death in most instances was massive hemorrhaging and compression, the result of being crushed and twisted by other walruses. Such mortality is not uncommon but usually involves small numbers of animals.

The relative contribution of each' type of natural mortality to the overall mortality rate is difficult to evaluate. Those mortalities, such as from stampedes, that occur on shore are more' obvious, although perhaps less frequent, than those that occur off shore, such as killer whale predation.

POPULATION DYNAMICS

As mentioned previously, it is difficult to obtain precise estimates of the size of the Pacific walrus population. Several factors contribute to that difficulty, including the vastness of the area over which the population is distributed (Fig. 1). Within that area the walruses are highly aggregated but with large variations in group size. As a result, 40% of the total area would have to be surveyed to obtain 95% confidence limits on an estimate within 10% of the true population size (Estes and Gilbert, 1978). Estimates are hindered also by variability in the proportion of animals under water at a given moment, hence invisible. Haul-out frequency shows no circadian rhythm but is affected by weather conditions (Fay and Ray, 1968; Estes and Gilbert, 1978).

The sex composition of the calves at birth is one male; one female (Nikulin, 1941; Brooks, 1954; Burns, 1965). Unfortunately, harvest data are too strongly biased towards males to give an indication of the sex composition of the population as a whole. Soviet workers have estimated from field observations of live animals that the sex ratio in the "adults" is 1:1 (Feedoseev, 1962; Krylov, 1968), but Chapskii (1936) and Fay (in prep.) point out that the ratio in breeding-age adults is closer to 1 male:3 females or 1:4.

More detailed knowledge of the breeding system could shed some light on the question of adult sex ratios and provide information about population productivity. Obtaining such knowledge has, unfortunately, been hampered by the inhospitable environment in which mating occurs. Allen (1880) and Krylov (1 968) concluded that walruses are monogamous, based on sightings of small "family" groups in spring. It is now recognized, however, that mating occurs in winter when larger aggregations are formed. Having presented evidence of a polygynous mating system, Fay et al. (1980) and Fay and Ray (1980) predicted a sex ratio favoring females as is the case with other polygynous pinnipeds (Bartholomew, 1970; , Stirling, 1975).

Whatever" the sex ratio of the population, it is clear that only 32 to 43 percent of the females breed in any given year (Freiman, 1941; Mansfield, 1958; Loughrey, 1959; Krylov, 1968; Burns, 1965; Gol'tsev, 1975) due to the long gestation and nursing periods. Clearly, productivity is relatively low in this mammal.

At the time of birth, calves are estimated to make up from 7 to 15 percent of the population (Chapskii, 1936; Burns, 1965; Drylov, 1968). Recruitment to breeding age is believed to be at an annual rate of at least 6 but not more than 10 percent (Chapskii, 1936; Loughrey, 1959; Mansfield, 1966; Krylov, 1968).

Because many population parameters are poorly known at present, information about the population's status is largely limited to indirect indicators. An increase in number of haul-out sites utilized since the 1950's and increased density on old sites are suggestive of an expanding population. Recent reports from Eskimo hunters suggest a possible change in food habits; reports of reduced blubber thickness of harvested walruses suggest 'declining quantity or quality of foods available. Both imply that the population is at or near the carrying capacity of the environment. Population estimates from aerial surveys in recent years have indicated a steep upward trend (Braham et al., 1979; Lowry et al., 1979) suggesting that the population may currently be about 200 thousand animals, as it was estimated to have been in its primitive state more than 200 years ago (Fay, 1957).

MANAGEMENT

Commercial taking of walruses was banned in the United States in 1941 (Brooks, 1953; Fay, 1957) and in the Soviet Union in 1957 (Krylov, 1968; Dosygin, 1975). Since that time only native hunters have been permitted to harvest walruses regularly in either country, taking a total of 2- 6 thousand per year and less than 100 per year were taken for scientific research. In this country, less than 70 per year have been taken by sport hunters. According to Burns (1965) and Krylov (1968) the loss rate, due to walruses being shot but not recovered, has been approximately 40 percent in recent years. Applying that loss rate to Soviet and American harvest data, the total kill from 1961 through 1977 is estimated to be from 3,000 to 7,000 walruses per year with an average of approximately 5,000 per year. Approximately 75 percent of the retrieved animals have been males; sexually-prime animals have made up the largest portion of the harvest.

Cooperative management of Pacific walruses by Soviet and American agencies will be necessary to insure the continued health of the population. Progress in achieving such cooperation has been hampered in part by a lack of continuity in management authority in this country. Authority for management of walruses passed from the United States Fish and Wildlife Service (USFWS) to the Alaska Department of Fish and Game (ADF&G) in 1958, back to the USFWS in 1972, again to the AD F&G in 1976, and was returned to the USFWS in 1979. Currently an application by the state for return of management authority over walruses (and eight other species of marine mammals) is pending before the USFWS and the National Marine Fisheries Service. Conflicts between state policies and those dictated by the federal Marine Mammal Protection Act (MMPA) of 1972 must be resolved before the state can resume management authority.

In the meantime the USFWS is charged with management under the MMPA which prohibits the taking of walruses with certain exceptions. Walruses may be taken under permit for scientific research or public display and by Eskimos, Aleuts, and Indians for use in "subsistence" and production of handicrafts and clothing. The MMPA and USFWS set no limits on the size or composition of the harvest.

POTENTIAL EFFECTS FROM OIL AND GAS DEVELOPMENT

The effects on walruses of direct contact with oil are unknown. Ingestion of petroleum products would likely be toxic and cause liver damage (Cornelius and Kanedo, 1963; Geraci and Smith, 1977). The relatively high mobility of walruses would presumably allow them largely to avoid oil spills except in a situation where spilled oil concentrated in leads and other openings in the ice.

Oiling experiments conducted on phocid seals indicate some potential impacts on walruses who are closely related and occupy a similar habitat. Three captive ringed seals *(Phoca hispida)* died of stress within 71 minutes after a 10 mm layer of crude oil was introduced into their laboratory holding tank (Smith and Geraci, 1975). In the same study, six other ringed seals survived a 24-hour exposure to crude oil in a pen immersed in a salt water pond. All of the seals exhibited eye irritation during the exposure but without permanent damage. Prolonged exposure might well have resulted in severe and, perhaps, permanent eye damage (Geraci and Smith, 1977). A few days after the oiling, the seals were killed and necropsied. Petroleum oil was detected in all organs except the lungs, kidney damage was evident in two seals, and one showed fatty changes in the liver (Smith and Geraci, 1975; Geraci and Smith, 1977).

Ingestion of up to 75 ml of crude oil produced no significant effects in ringed seals, but 5 and 10 ml of carbon tetrachloride caused liver damage in grey seals, *Halichoerus grypus* (Geraci and Smith, 1977). Seal mortalities due to oil plugging body orifices and immobilizing pups also have been reported (Geraci and Smith, 1977).

With the exception of immobilization, all of the detrimental effects observed in phocid seals from petroleum products could reasonably be expected to occur in walruses. The stress reaction could be most acute in molting walruses, the molt being a time of stress for pinnipeds (Riviere et al., 1977; Geraci and Smith, 1977).

Walruses will leave a haul-out in response to the presence of man. Continued harassment may prevent recolonization of haul-out sites (Fay pers. comm.; Burns pers. comm.). Noise from aircraft is known to cause stampedes from shore and ice haul-outs (Tomilin and Kibal'chich, 1975). Human activity in and around oil field development and production structures could be expected to displace walruses from the vicinity.

Structures that change the patterns of polyni, leads, and tide-cracks in the ice could alter walrus distribution inasmuch as heavy ice cover limits that distribution. Conceivably, walruses might overwinter in a previously unused location due to open water created by a man-made structure but the noise and activity associated with that structure is just as likely to displace the animals. In any event, such events probably would not affect more than a few 'walruses.

Greater potential impacts on the walrus population may result from development activities that adversely affect the benthos of the Bering or Chukchi shelves. Mortality of several kinds of benthic invertebrates including bivalve mollusks has been observed as a direct affect of petroleum oil spills, but this apparently is limited to animals in the immediate vicinity of the spill (North, 1967; Percy and Mull in, 1975). Sublethal effects may, however, have a far greater impact, since there is evidence that they can greatly reduce productivity. Productivity of soft-shelled clams *(Mya arenaria)* decreased 20% in two years after an oil spill, while clams in a neighboring, uncontaminated bed showed a 250% increase in productivity associated with natural "coastwide improvement in environmental conditions" (Dow, 1975). Gilfillan et al. (1976) found that the carbon uptake of *M. arenaria* exposed to No. 6 fuel oil was only half of the uptake by uncontaminated clams. Feeding by the arctic bivalve, *Yoldiella intermedia*, was found to be temporarily halted by exposure to crude oil in the water (Percy and Mullin, 1975).

Oil contamination causes shell closing in cockles *(Cardium edule)*, mussels *(Mytilus edulis)*, and oysters *(Ostrea lurida)* and can cut respiration rates by over 50% in mussels *(Brachidontes variabilis)* and clams *(Donax trunculus)* (Johnson, 1977). Abnormal development of, and inhibition of settlement by, bivalves has also been documented as resulting from oil contamination (Renzoni, 1975; Johnson, 1977). The clams, *Mya arenaria* and *Macoma balthica*, have been reported to leave their burrows in response to oil contamination of the sediments (Taylor et al., 1976; Johnson, 1977).

Once in the sediments, oil is likely to have long-term effects. In the arctic and subarctic marine environment, the problem is compounded by the relatively slow degradation of oil in the cold sediments and by the intermittent redeposition of those sediments by currents (Clark and Finley, 1977). Productivity of the benthic foods of the walrus could, therefore, be impaired for long periods of time and over greater areas than effected by the initial spill.

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